IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	Charles W.C. Lin
Title:	SUPPORT CIRCUIT WITH A TAPERED THROUGH-HOLE FOR A SEMICONDUCTOR CHIP ASSEMBLY

Serial No.:	Unknown	Filed:	Herewith
Examiner:	Unknown	Group Art Unit:	Unknown
Atty. Docket No.:	P012-1		

ASSISTANT COMMISSIONER FOR PATENTS
Washington, D.C. 20231

PRELIMINARY AMENDMENT

Dear Sir:

Please amend the application as follows.

In the Title

Replace the Title with SUPPORT CIRCUIT WITH A TAPERED THROUGH-HOLE FOR A SEMICONDUCTOR CHIP ASSEMBLY

In the Specification

Insert the following heading and paragraph at page 1, line 1:

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is divisional of U.S. Application Serial No. 09/665,931 filed on September 20, 2000.

Replace the paragraph at page 6, lines 13-32 with the following paragraph:

U.S. Patent No. 5,722,162 discloses fabricating a pillar by electroplating the pillar on a selected portion of an underlying metal exposed by an opening in photoresist and then stripping the photoresist. Although it is convenient to use photoresist to define the location of the pillar, electroplating the pillar in an opening in the photoresist has certain drawbacks. First, the photoresist is selectively exposed to light that initiates a reaction in regions of the photoresist that correspond to the desired pattern. Since photoresist is not fully transparent and tends to absorb the light, the thicker the photoresist, the poorer the penetration efficiency of the light. As a result, the lower portion of the photoresist might not receive adequate light to initiate or complete the intended photo-reaction. Consequently, the bottom portion of the opening in the photoresist might be too narrow, causing a pillar formed in the narrowed opening to have a diameter that decreases with decreasing height. Such a pillar has a high risk of fracturing at its lower portion in response to thermally induced stress. Second, if the photoresist is relatively thick (such as 100 microns or more), the photoresist may need to be applied with multiple coatings and receive multiple light exposures and bakes, which increases cost and reduces yield. Third, if the photoresist is relatively thick, the electroplated pillar may be non-uniform due to poor current density distribution in the relatively deep opening. As a result, the pillar may have a jagged or pointed top surface instead of a flat top surface that is better suited for providing a contact terminal for the next level assembly.

Replace the paragraph at page 18, lines 3-18 with the following paragraph:

FIGS. 1P, 2P and **3P** are cross-sectional, top and bottom views, respectively, of the semiconductor chip assembly after ball bond connection joint 80 is formed. Ball bond connection joint 80 is formed in through-hole 62, extends through opening 60 in adhesive 54, and contacts pad 78 and routing line 42, thereby electrically connecting pad 78 and routing line 42. Ball bond connection joint 80 is composed of gold and is formed by thermosonic wire bonding, although thermocompression wire bonding can also be used. Ball bond connection joint 80 fills openings 52 and 60 and extends into opening 58 but does not contact insulative base 40. Thus, the sidewalls of opening 58 remain exposed and devoid of metal. Moreover, ball bond connection joint 80 only contacts portions of pad 78, routing line 42 and adhesive 54 exposed by through-hole 62 and is the only electrical conductor in through-hole 62. Ball bond connection joint 80 provides a robust, permanent electrical connection between pad 78 and routing line 42.

Further details about a ball bond connection joint are described in U.S. Application Serial No. 09/665,928, filed September 20, 2000 by Charles W.C. Lin entitled "Semiconductor Chip Assembly with Ball Bond Connection Joint" which is incorporated by reference.

Replace the paragraph at page 18, line 31 to page 19, line 13 with the following paragraph:

The conductive trace can have various shapes and sizes and can be various conductive metals including copper, gold, nickel, aluminum, tin, combinations thereof, and alloys thereof. Of common metallic materials, copper has especially low resistivity and cost. Furthermore, those skilled in the art will understand that in the context of a support circuit, a copper conductive trace is typically a copper alloy that is mostly copper but not pure elemental copper, such copper-zirconium (99.9% copper), copper-silver-phosphorus-magnesium (99.7% copper), or copper-tin-iron-phosphorus (99.7% copper). The conductive trace may be compatible with receiving the connection joint before the opening in the routing line is formed, thereby obviating the need for spot plated metal on the routing line before the connection joint is formed. The conductive trace may function as a signal, power or ground layer depending on the purpose of the associated chip pad. The conductive trace need not necessarily extend above the top surface of the insulative base, and the top portion of the conductive trace can be a ball, a pad, or a pillar (columnar post). A pillar is particularly well-suited for reducing thermal mismatch related stress in the next level assembly.

Replace the paragraph at page 23, lines 22-26 with the following paragraph:

Various changes and modifications to the presently preferred embodiments described herein will be apparent to those skilled in the art. For instance, the materials, dimensions and shapes described above are merely exemplary. Such changes and modifications may be made without departing from the spirit and scope of the present invention as defined in the appended claims.

In the Claims

Cancel claims 1-50 without prejudice or disclaimer to the subject matter recited therein.

Amend the following claim:

51. (Amended) A support circuit adapted to be mechanically and electrically coupled to a semiconductor chip such that the support circuit and the chip in combination form a semiconductor chip assembly, the support circuit comprising:

an insulative base; and

a conductive trace embedded in the insulative base, wherein the conductive trace is a single continuous piece of metal, the conductive trace includes a pillar that extends above the insulative base and a routing line that is substantially covered by and extends below the insulative base, and an opening in the routing line has tapered sidewalls and a diameter that increases as height increases.

Add the following claims:

61. A support circuit adapted to be mechanically and electrically coupled to a semiconductor chip such that the support circuit and the chip in combination form a semiconductor chip assembly, the support circuit comprising:

an insulative base; and

a conductive trace embedded in the insulative base, wherein the conductive trace is a single continuous piece of metal, the conductive trace includes a pillar that extends through and above the insulative base and a routing line that is substantially covered by and extends below the insulative base, an opening in the routing line has tapered sidewalls and a diameter that increases as height increases, and the routing line is a planar metal lead that provides horizontal routing between the pillar and the opening.

62. The support circuit of claim 61, wherein the insulative base includes an opening that exposes the opening in the routing line and a portion of a top surface of the routing line adjacent to the opening in the routing line.

63. The support circuit of claim 61, wherein the support circuit includes a through-hole that consists of the opening in the insulative base and the opening in the routing line.

64. The support circuit of claim 61, wherein the tapered sidewalls have a slope of about 45 to 75 degrees.

65. The support circuit of claim 61, wherein the pillar extends a first distance above the routing line, the insulative base extends a second distance above the routing line, and the first distance is at least twice the second distance.

66. The support circuit of claim 61, wherein the pillar has a flat top surface and a diameter that is narrowest at the top surface.

67. The support circuit of claim 66, wherein the pillar has a continuous taper between the top surface and the routing line.

68. The support circuit of claim 61, wherein the conductive trace is copper and the insulative base is epoxy.

69. The support circuit of claim 61, wherein the support circuit is devoid of wire bonds, TAB leads, and solder joints.

70. The support circuit of claim 61, wherein the semiconductor chip assembly is a chip size package.

VERSION WITH MARKINGS TO SHOW CHANGES MADE

In the Title

The Title has been amended as follows:

~~METHOD OF MAKING A~~ SUPPORT CIRCUIT WITH A TAPERED THROUGH-HOLE FOR A SEMICONDUCTOR CHIP ASSEMBLY

In the Specification

The heading and paragraph at page 1, line 1 have been inserted as follows:

<u>CROSS-REFERENCE TO RELATED APPLICATIONS</u>

This application is divisional of U.S. Application Serial No. 09/665,931 filed on September 20, 2000.

The paragraph at page 6, lines 13-32 has been amended as follows:

U.S. Patent No. 5,722,162 discloses fabricating a pillar by electroplating the pillar on a selected portion of an underlying metal exposed by an opening in photoresist and then stripping the photoresist. Although it is convenient to use photoresist to define the location of the pillar, electroplating the pillar in an opening in the photoresist has certain drawbacks. First, the photoresist is selectively exposed to light that initiates a reaction in regions of the photoresist that correspond to the desired pattern. Since photoresist is not fully transparent and tends to absorb the light, the thicker the photoresist, the poorer the penetration efficiency of the light. As a result, the lower portion of the photoresist might not receive adequate light to initiate or complete the intended photo-reaction. Consequently, the bottom portion of the opening in the photoresist might be too narrow, causing a pillar formed in the narrowed opening to have a diameter that decreases with decreasing height. Such a pillar has a high risk of fracturing at its lower portion in response to thermally induced stress. Second, if the photoresist is relatively thick (such as 100

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FIGS. 1P, 2P and **3P** are cross-sectional, top and bottom views, respectively, of the semiconductor chip assembly after ball bond connection joint 80 is formed. Ball bond connection joint 80 is formed in through-hole 62, extends through opening 60 in adhesive 54, and contacts pad 78 and routing line 42, thereby electrically connecting pad 78 and routing line 42. Ball bond connection joint 80 is composed of gold and is formed by thermosonic wire bonding, although thermocompression wire bonding can also be used. Ball bond connection joint 80 fills openings 52 and 60 and extends into opening 58 but does not contact insulative base 40. Thus, the sidewalls of opening 58 remain exposed and devoid of metal. Moreover, ball bond connection joint 80 only contacts portions of pad 78, routing line 42 and adhesive 54 exposed by through-hole 62 and is the only electrical conductor in through-hole 62. Ball bond connection joint 80 provides a robust, permanent electrical connection between pad 78 and routing line 42. Further details about a ball bond connection joint are described in U.S. Application Serial No. **09/665,928**~~________~~, filed **September 20, 2000**~~concurrently herewith (attorney docket no. P007)~~ by Charles W.C. Lin entitled "Semiconductor Chip Assembly with Ball Bond Connection Joint" which is incorporated by reference.

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such copper-zirconium (99.9% copper), copper-silver-phosphorus-magnesium (99.7% copper), or copper-tin-iron-phosphorus (99.7% copper). The conductive trace may be compatible with receiving the connection joint before the opening in the routing line is formed, thereby obviating the need for spot plated metal on the routing line before the connection joint is formed. The conductive trace may function as a signal, power or ground layer depending on the purpose **of** the associated chip pad. The conductive trace need not necessarily extend above the top surface of the insulative base, and the top portion of the conductive trace can be a ball, a pad, or a pillar (columnar post). A pillar is particularly well-suited for reducing thermal mismatch related stress in the next level assembly.

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an insulative base; and

a conductive trace embedded in the insulative base, wherein the conductive trace is a single continuous piece of metal, the conductive trace includes a pillar that extends above the insulative base and a routing line that is substantially covered by and extends below the insulative base, **and** ~~wherein~~ an opening in the routing line has tapered sidewalls and a diameter that increases as height increases.

Claims 1-50 have been cancelled.

Claims 61-70 have been added.

REMARKS

Claims 51-70 are pending. In this Preliminary Amendment, claims 1-50 have been canceled, claim 51 has been amended and claims 61-70 have been added. In addition, the Specification has been amended to improve clarity. No new matter has been added.

In view of the amendments and remarks set forth herein, the application is believed to be in condition for allowance. Should any issues remain, the Examiner is encouraged to telephone the undersigned attorney.

Respectfully submitted,

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